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Chief Engineer CHAS. H. BAKER in the chair.

In the absence of the author, P. A. Engineer W. L. Nicoll read the following paper on

THE U. S. SHIP TRENTON.

BY GEO. W. BAIRD, PASSED ASSISTANT ENGINEER, U. S. N.

An Inspection of this fine vessel will show that our Naval Authorities have well improved their time since the termination of our late war, and have profited by the costly experiments which have so advanced the great Navies of Europe.

The "*Trenton*" is one of the "eight sloops" recently completed, and like all modern unarmored ships of war, is intended for a commerce destroyer.

Indeed, the high speed and great weight of armor now demanded have rendered inevitable the division of ships into several classes. This, however, our own Naval Authorities were the first to recognize and to put in practice. The principal improvements in the "*Trenton*" are in the steam machinery and the ordnance, the former of which I am invited to write about; but that this paper may be more comprehensive I will introduce the dimensions of the hull and other data on which depends the performance of the machinery.

THE HULL.

The vessel has by no means a sharp model, being designed to carry four guns in the bow, all of which can bear directly forward. Amidships she has scarcely a perceptible dead rise, but her keel increases in depth from 1 ft. 8″ for'd to 2 ft. 8″ aft.

She has great breadth of beam in proportion to her length. The hull is of wood, is coppered, is rigged as a ship, and has the following dimensions.

Length over all, in feet and inches,	271–6
Length on the load water line in feet,	253.
Depth of hold from throat of gun-deck, in feet and inches,	23–4
Draught of water at launching { forward,	10–2½
Draught of water at launching { aft,	14–4½
Displacement per inch of draught, { at 20 feet, }	22.8
Displacement at deep load line, in tons, { 8 in. draught, }	3900
Extreme breadth of beam, in feet,	48
Area of greatest immersed transverse section in square feet,	780.
Area at load line (at 20 ft. 8 in. draught) in square feet,	9576.
Center of gravity of displacement aft of greatest immersed transverse section, in feet and inches,	10–4
Distance of greatest immersed transverse section from stern-post, in feet and inches,	137–10
Ratio of length to breadth on the load water line,	5.271 to 1.000
Ratio of displacement to its circumscribing parallelopipedon,	0.6131 to 1.000

Engine.

There is, for the propulsion of the ship, a compound engine having one high pressure and two low pressure cylinders. The two latter are connected to cranks, which are placed upon the shaft at right angles to each other, while the crank of the high pressure cylinder bisects the angle between them, or is placed at an angle of 135 degrees with either low pressure crank. The low pressure valve chests, the exhaust passage of the high pressure engine, and the pipes connecting them, form the receiver, the aggregate volume of which is 90 ½ cubic feet, or 1.21 times the volume swept by the high pressure piston.

Each low pressure cylinder exhausts into a separate condenser, but the condensers can be connected if desired.

The cylinders are arranged on the starboard side of the hold, the high pressure being in the middle. The engine is of the horizontal, back acting type. The valves are double ported slides, with lap on both the steam and exhaust sides. The steam lap is sufficient to cut off the steam at 6-10 of the stroke of the pistons. The high pressure has an independent cut off on the back of the valve and the point of cutting off is varied by the usual right and left hand screw arrangement. The valves are worked by Stephenson's links and eccentrics.

Air, feed and bilge pumps are worked from arms on the side rods.

The air pumps are double acting piston pumps, packed with lignum-vitae and hemp, and have rubber valves.

The cylinders are steam-jacketed and felted. The valve chests are felted and lagged.

The condensers have brass tubes, well tinned, placed horizontally and in two nests; the circulating water passing once through the tubes of each nest. The tubes are ⅝ of an inch outside diameter and the steam is condensed on the outside. They are secured in cast iron tube sheets by wood packing.

The Design.

The compound engine and high pressure boilers were designed for the purpose of giving the vessel the highest mean rate of speed, and the greatest possible length of voyage. The unit of measurement of a vessel is her displacement. A certain definite space is allotted for battery, for machinery and fuel, for stores, ammunition etc., and within the weight and space alloted for machinery and fuel the Bureau of Steam Engineering has so distributed the constituents, as to approach very nearly the highest possible mean.

The increase in the economic efficiency of the marine engine has advanced with the increase of steam pressure, higher grades of expansion, and velocity of piston. In each of these three essential advances, our own countrymen have been foremost. There appears, from the most reliable experiments, to be a certain degree of expansion due to each definite steam pressure, if the maximum economy would be obtained, and as far as the unqualified *economy* of the fuel goes, it is not probable that any fair-minded engineer will claim supremacy for the compound, over the simple, arrangement of engine, or, *vice versa*. Other functions enter, which will probably be interesting to the Institute, and will be shown. For non-jacketed simple condensing engines, using steam at 25 lbs. pressure above the atmosphere, Chief Engineer Isherwood found that the economic point of cutting off was four tenths (4-10) from the commencement of the stroke of the piston. A non-condensing engine would needs follow about one-half stroke, in order to attain its greatest economy. At 75 pounds pressure these figures would be about one-fifth (1-5) for the condensing, and about one third (1-3) for the non-condensing engine.

The use of a steam jacket, by which the cylinder is enveloped by steam of the boiler pressure and temperature, changes the conditions sensibly. The saving by this means is elaborately set forth in the

Bureau's report for the year 1875, which, being in the archives of the Institute, does not require comment here.

The two features which make the compound engine superior to the single expansion (or simple) engine are, 1st, the lighter working parts; and, 2d, the greater uniformity of its turning forces.

As an example of the former, we may take the engines of the *Trenton*. It is intended to attain a piston velocity of 448 feet per minute, to use 80 lbs. of steam, above the atmosphere, with 2.75 expansions in the high pressure cylinder, or a total range of 14 expansions.

There are three cylinders, and each is intended to be of equal power. The two low pressure cylinders are 78 inches in diameter and the high pressure is 58½. The pistons have a stroke of four feet.

Now it must be borne in mind that all parts of machinery are proportioned to the maximum strain. In a steam engine this occurs at the commencement of the stroke of the piston.

The power is made up of the mean weight upon the pistons multiplied into their velocity. A single cylinder, single expansion engine, which carried the same initial pressure and same mean pressure as the high pressure engine of the *Trenton*, and which exhausted into the condenser with the vacuum attained here would require to be 63½ inches in diameter, or nearly 15 per cent. larger than the present H. P. cylinder. This would increase the sizes of the piston and connecting rods in the same ratio. Indeed it would carry a large increase of size and weight throughout most of the engine.

It was the intention of Chief Engineer Wood, late Chief of the Bureau of Steam Engineering of the Navy Department, to design for two vessels of the "*Miantonomah*" class (now re-building) compound engines and for two others simple engines, all of the vessels having hulls, boilers and propellers exactly alike. Indeed he intended to have had all the engine framing, working parts of the engine, condensers, pumps etc., exactly alike; the same aggregate volume of cylinder and the same grade of expansion; but on calculating the strain on working parts, the area of piston needed, etc., it was ascertained that the maximum weight (or pressure) upon the pistons would be twenty four (24) per cent. greater in the simple engine than in the compound.

Uniformity of the Turning Forces.

Figure I is a diagram of the turning forces of the engine, with the three cylinders in use. a, a, a, represent the variation of pressure in the high pressure engine, and b, b, and c, c, that in the two low press-

ure engines. The curve A, A, is the combined resultant, and its variation shows the variation of torsion on the shaft, leaving inertia out of consideration. Had the cranks been connected at 120° (or equidistant) then the torsion would vary as the line B, B. It will be observed that though the engine has three cylinders, there are but two distinct and decided increments during a complete revolution.

It will also be observed that the turning force is more uniform with the cranks in their present relative positions. It will be remembered that the crosshead of the after, (low pressure) engine was broken on the 10th of March, since which time the after engine has been disconnected and out of use. With only two engines in use it is more difficult to start or reverse them, than if the cranks were placed at 120° from each other. To ascertain what relative effect this would have on the turning forces, Fig. 2 has been constructed, in which the curved line, A, A, A, shows the variation of torsion upon the shaft with the cranks, as at present arranged, and the dotted line shows what the torsion would have been, had the cranks been arranged at an angle of 120° apart.

In this diagram, as in the other, there are but two definite pulsations per revolution, and they follow the variations of the high pressure engine. The sharp angles which occur in these diagrams, or, in other words, the sudden change in the intensity of the turning forces would be greatly modified, had the inertia of the moving parts of the engine been considered; but inasmuch as these diagrams are merely comparative, and refer only to the distribution of the work, so far as the piston pressures are concerned, they have been confined exclusively to that purpose.

It may not be out of place to compare a diagram* of our most successful single expansion engines, with those of the "*Trenton*." Fig. 3 is a diagram of the turning forces of the engines of the "*Pensacola*," using 40 pounds pressure and expanding four times. This is a higher grade of expansion than this class of engines usually employed, though it is the exact point at which the Bureau proposed to cut off, in adapting the engines of the "*Worcester*" to the "*Lancaster*." (Vide Report of Sec. of the Navy for 1876), though it is not nearly so high a grade as is employed in the compound engines generally. These have been unanimously accorded to be the best working, simple screw propeller engines in the Navy; though it will be observed that the variation,

*I am indebted to Asst. Engineer I. A. Henderson, U. S. N., for the construction of these torsion diagrams.

even at so low a grade of expansion, is considerable, and the number of pulsations per revolution is just double that of the "*Trenton's.*" These sudden, though uniform, variations in the extent of torsion on the shaft, have, in my opinion, a decided influence on the shaking of the ship. If one of the blades of the screw propeller pass the stern post at the instant of the greatest torsion (and velocity) of the shaft, and if this number of beats per unit of time accords with the natural vibration of the vessel, it is natural that the latter should respond to the former, until great motion ensues: exactly as the march of infantry over a bridge endangers it, unless they break step. If, however, the blades of the propeller be so arranged that they are not opposite the rudder post at the instant of greatest torsion, this danger is reduced. However, I am of the opinion that where a propeller with an odd number of blades is used, this difficulty is partially overcome.

I have prepared Fig. IV. to show the variation in torsion of a three cylinder, single expansion (or simple) engine using the same initial pressure, the same total unbalanced pressure, the same number of expansions and the same velocity of piston as are employed in the "*Trenton.*"

This example is theoretical, and is calculated for the full power of the engine, while Fig. I. has been draughted from indicator diagrams taken before the after engine was placed out of use, (with broken cross-tail) at which time, unfortunately, the power developed was only about two thousand (2000) horses. In the example given in Fig. IV, it is assumed that the engines are connected at 120° with each other. A comparison of Figs. I. and IV. will show, graphically, the merits of the two systems in regard to their uniformity in turning forces.

Reversing Gear.

A pair of oscillating engines, under the engine-room platform, raise and lower the links through the intervention of a spiral gear. The motion of the oscillating cylinders upon their trunions opens and closes the ports, and the motor is reversed by a two-way cock, which changes the steam-port into an exhaust-port, and *vice versa*. This arrangement essentially deprives the machine of "lap or lead," and keeps the exhaust open up to the termination of the stroke, which gives the advantage of always clearing itself of water; and no matter how suddenly a signal is received to stop, or reverse, the engines, no fear need be entertained of damaging the reversing engine by the water that is certain to accumulate in the steam pipe.

On leaving the Navy Yard, New York, on the 5th of March last, I gave this system a trial, and found that the time required to throw the links from full ahead to full back gear was only six seconds. This was with the boiler pressure of 75 pounds on the valves of the main engine. An automatic arrangement shuts off the steam when the links reach full throw.

Boilers.

The boilers are eight in number, and cylindrical in form. They are arranged in rows (with their axes athwart-ship), four on each side of the hold, and discharge their products of combustion into a common smoke-pipe, which latter is telescopic.

Each boiler is 12 feet in diameter and 10 feet 3 ins. in length, on line of axis, and contains three furnaces. The furnaces are cylindrical, 36 inches internal diameter, exposing a length of grate of 6 feet and 11 inches. The tubes are of brass, are arranged in nests, horizontally, above the furnaces, and are 3¼ inches outside diameter, and 8 ft. 2½ ins. in length. Each boiler has a safety valve, a check valve, a bottom, and a surface, blow valve, a stop valve, and steam and water guages. They discharge their steam into a common pipe which enters the uptake, and passes twice its length. The pipe thus acts as a superheater.

The boilers are entirely below the water, their highest points being about 24 inches below the water level when the coal bunkers are empty. All the coal is carried outboard of the boilers, there being no forward bunkers. A shot would have to pass through twelve feet of coal, even on the berth deck, before it could reach the boilers, so they can be considered as being well protected. It is a fact, patent to all, that no vessel in our Navy, the boilers of which were masked by the water, has ever received a shot into them.

Steam Pumps.

The circulating pumps for the condensers are independent, centrifugal ones, and are two in number. They are driven by a pair of vertical steam engines, and are upon the same shaft. The estimated capacity of these pumps is five thousand (5000) gallons of water per minute. They are situated about eight (8) feet below the water level, and have, therefore, that head to assist them. They are provided with bilge valves; but inasmuch as they would have to lift the bilge-water, it is estimated that their capacity as bilge pumps would not be more than half the above figure.

The auxiliary (or Donkey) pumps are two in number, and are of the

Blake patent. They are horizontal, double acting, and have a capacity of three hundred and fifty (350) gallons per minute. These pumps may be used for pumping water out of, or into, the boilers, for pumping the bilges, for fire purposes, or, as auxiliary air-pumps to the main condensers. They have, so far, proved themselves to be the best auxiliary steam pumps I have ever used, the only thing not in their favor being that there is no means of working them by hand. The combined capacity of the steam bilge pumps of the vessel is estimated at three thousand two hundred (3200) gallons per minute.

Steam Windlass.

This machine was built by the Providence Steam Engine Company, from the plans of the ingenious engineer, Mr. Frederick Sickles. It is essentially a horizontal revolving shaft placed athwartships on the forward part of the berth deck, and upon which shaft is secured the "wild cats" for carrying the chains, drums for carrying ropes to be used in catting and fishing the anchor, and at the middle of the drum a spiral gear wheel is placed which is driven by a pair of engines placed beneath the deck. The "wild cats" are secured to the shaft by means of movable keyes, which enable the attendant to veer chain on one anchor and hoist the other at the same time. A friction gear enables the attendant to check the chain when veering, at any moment.

The steam cylinders are 14 inches in diameter of bore and have 14 inches stroke of piston. An automatic valve, placed on the steam pipe near the engine, prevents the pressure from rising above 30 lbs. per sq. in. on the pistons, no matter what excess we have in the boilers. In usefulness and in convenience this machine is admirable. The sharp angle at which the chains pass the hawse pipes increases the resistance to such an extent that the thrust bearing of the spiral gear heats, and when breaking the anchor out of the mud the hand gear is used, to assist the engines, as a precaution. The hand gear is an ordinary pump brake, and may be used with the steam gear or independently of it. The "wild cats" may be unkeyed and the engine used to "cat" and "fish" the anchors.

Steering Engine.

This machine is from the same builders and designer as the Windlass. It is placed on the gun-deck between the steerage and ward room hatches, with its axis fore and aft, and its drum is connected to the tiller by means of hide ropes. The engine consists of a pair of cylinders, inclined at an angle of 45° and connected to the same crank.

The drum which carries the tiller ropes is keyed to the crank-shaft. That which distinguishes this from the ordinary steam engine, and makes it particularly valuable for the purpose of steering, is its valve gear. This system is mounted upon the engine frame in front of the engine, and is actuated by a hand wheel, which in turn is moved by a similar wheel, on the spar-deck, through the intervention of a drum and cord. Any motion of the valve gear admits steam to the engine, and any motion of the engine tends to bring its valves to the middle position, and the mechanism is so graduated that every degree of angular motion given to the hand wheel is responded to by exactly the same amount of angular motion in the engine. The steam cylinders have a diameter of 24 inches and a stroke of piston of one foot, and though the hand wheel may be worked by a child, yet the turning force of the engine, which responds to it, is enormous. The working of this machine is not smooth and can never be made so. The pressure of steam upon the pistons urges them forward until the motion has brought the valves to their middle position. Here the ports are all closed and there is no pressure to impel nor to impede the motion of the engine. But the inertia of the moving parts of the engine is sufficient to move it a short distance past the dead point, and this motion, communicated to the valve gear, admits steam on the opposite side and brings the engine back. Instead of stopping exactly upon the dead point it passes and repasses several times and is only brought to rest by a friction brake which the builders have attached.

Steam Winches.

In the boiler hatch, and secured to the coamings on the gun-deck, are placed two rotary engines of the Lidgerwood patent. They each drive a drum through the intervention of a friction gear and are reversed on the same principle as the *reversing engine*. The drums carry cords for the purpose of hoisting ashes, or for coaling ship. These rotary engines were intended by the superintending engineer to hoist the smoke pipe, but, as at present arranged, cannot be employed for that purpose.

Distilling Apparatus.

This machine is of the kind patented by the writer, and has been too long in use in the Navy to warrant any comment here.

Speed of the Vessel.

The accident to the crosstail of the after engine, on the day the ship left New York, (five months ago), made it necessary to disconnect that

engine and run with the other two. By this arrangement but one condenser is in use and, therefore, more than half the power cannot be employed. With half the power the ship has frequently logged 11¼ knots under steam alone, uninfluenced by wind or current. The preparation of this paper has been postponed in the vain hope of seeing the damaged engine repaired, and a test made for speed. Supposing that the power varies as the cube of the speed, the vessel will attain a maximum rate of 14½ knots per hour, on the estimated full power of 3000 indicated horses. Although there is every indication that a maximum of 3000 indicated horse power will be attained, yet, with the full model of the "*Trenton*," it cannot be expected that the speed will vary exactly as per the law above cited, and if 14 knots is ever attained, the most sanguine hopes of the designers and builders will be realized.

Effectiveness as a Ram.

The great strength and peculiar construction of the bow, and the great power of the vessel, will make her very effective as a Ram. Steaming at 14 knots, and striking another vessel at rest, the energy exerted would be $\frac{W}{g}V^2 = 25{,}868$ foot tons, or sufficient to raise the whole weight vertically a little over six and a half feet.

This is equal to the concentrated fire of ten of the eleven 8-inch rifle guns (that compose the battery) of the vessel, with the projectiles having a striking velocity of 1450 feet per second. Such a blow would crush in the armored side of any vessel yet built. The "handiness" of the vessel, which is truly remarkable, will make it not difficult to strike her adversary when, and wherever, her commanding officer wishes.

Warming, Lighting and Ventilating.

The vessel is warmed by steam heaters, known as Walton's "Radiators," which are supplied with steam from the main boilers, and discharge their condensed water through a Nason's trap into a tank from whence it is taken for washing purposes. These heaters being *noiseless*, merit a special mention. The device consists of an upper and lower chamber which are connected by iron pipes 1¼ inches in external diameter, the lower chamber being used for the purpose of collecting the water. As each pipe empties itself freely, and there is no flow of steam to retard or back up, the flow of water, that objectionable noise (which resembles a hydraulic ram) is entirely avoided.

The exposed surface of these heaters is nearly one square foot for each one hundred (100) cubic feet to be warmed, and the mean temperature of 74° F. was maintained in the ward room, when both hatches were open, and the temperature of the external atmosphere was 30° F. The temperature near the radiators was, of course, much greater; but the mean of six thermometers, placed at equal distances apart, on the centre line of the ward-room, gave the above quantity.

The large area and convenient arrangement of the hatches of the "*Trenton*" do not compensate for the diminutive size and unequal spacing of the air ports. It is true that all holes in a wooden ship should be cut equally between the timbers, and that the timbers may be spaced in reference to the location of the guns and other weights; but there is no apparent reason why the air ports should not have been more numerous and of greater size. Most of the officers' staterooms have each one air port; but some of them have only half a port, and others have one and a half. No one air port gives sufficient light to enable one to write ten feet from it. The vessel is lighted, at night, by oil lamps, and, except in the cabins, ward room and the offices of the Admiral and Captain, where argand burners are used, the vessel is as dark and dismal as the average U. S. ship of war. Special attention has been paid to the lighting of the engine room, where the most approved oil lamps are used; but the light is insufficient.

The danger and labor of trimming lamps that illuminate the most important moving parts of engines have usually prevented their sufficient use.

With the improved apparatus for manufacturing gas from the products of petroleum which are within our reach, there are many reasons why we should use it. It gives a better and a cheaper light than oil lamps; the labor of manufacturing it on board is less than that required to fill, clean and trim the lamps, and it is much more cleanly, and, for fixed lights, it is safer.

There are no unusual means for ventilating the ship, except two 8½ inch pipes extending from the after end of the shaft alley, up and out through the stern of the ship, and a number of oblong openings between the beams under the gun and spar decks. The latter were made for the purpose of ventilating the bilge. Those which were in the staterooms of the ward-room officers have been stopped up. The Constructor has stated that the openings into the officers' quarters were not intended to be permanent, but were for use only during the long period required to build and fit out the ship.

The two small pipes from the after end of the shaft alley are doing good work. With a wind aft, a current is forced in, and is felt in the alley; also, when the wind is ahead, there is an inward current caused no doubt by the wind eddying round the stern; but in a calm, or when the wind is a-beam, the pipes act as chimneys, and the current is strong enough to deflect the flame of a lamp very decidedly. Under any and all conditions there is a current of air through these tubes, either one way or the other. There is one other unusual means of ventilation (though not intended for that purpose), which merits mention. In order that room might be given on the gun deck to permit two guns to bear directly forward, the chains were brought in on the berth deck. The hawse pipes, through which the chains pass, are most excellent ventilators, when the ship is swinging head to the wind. The ship is supplied with the usual windsail, and the stationary ventilators for the fireroom. The berth deck, though warm when the vessel is under steam, is by far the most pleasant that I have seen. Inside the smoke pipe, and running as high as the standing part, there is a pipe which opens into and discharges the air from the fireroom. This arrangement was first devised for the "*Richmond*," in 1867, by the Chief of the Bureau of Steam Engineering; but, as it impeded the draught, it was abandoned. The boilers of the "*Trenton*" have so strong a draught, that the use of the pipe is permissible, and from it benefit is derived. In the event of using full power, where it would be necessary to force the fires, the lower opening of this pipe will be closed by a suitable door. On the gun deck there are no bulk heads around the boiler hatch, and, as most of the crew are berthed on this deck, and the temperature near the boiler hatch is high when there is steam, Rear Admiral Worden directed that a curtain be hung around the hatch. To determine the benefit of this curtain, a thermometer was hung on a hammock hook on the gun deck, another in the hatch just above the gun deck, another in the hatch just above the birth deck, and one in the fire room level with the uptake doors, out of the draft of the ventilators, at which place the temperature was greatest. The two thermometers in the hatch, and the one in the fire room were in the same vertical line. The readings were as follows:

Location of Thermometer.	Curtain Hung.	Curtain Removed.
Suspended to a hammock hook on the Gun-deck adjacent to the boiler hatch,	80	87°
Suspended in hatchway above level of gun-deck,	129	110°
Suspended in hatchway above level of berth-deck,	138	142°
Suspended in fire-room out of draught of wind sails.	145	160°

A lighted candle placed in the opening under the curtain, indicated an inward draught. It is not to be supposed that the temperature recorded in the last line is "the temperature of the fire room" of this fine ship: it is the temperature at a point in front of the uptakes, the warmest place in the fireroom, and from 30° to 40° warmer than that in which the firemen live. Under the ventilators, or the windsail, the temperature is as low as it is on deck.

The Bilges.

In the design and construction of the *Trenton*, attention appears to have been given to this subject. The limber holes are the largest I have observed in any of our sloops, and the floors, from the fore hold aft, are high enough for a man to pass under. One of the bulkheads of the shaft alley, which rested on the main kelson, prevented the space under the after shell room from being cleaned, but the bottom part of it has been cut away, and the offensive matter which had accumulated there has been removed, and it is now cleaned with the rest of the bilge, semi-weekly. Owing to leaks in the bow (probably some of the bolts that secure the ram) a small stream of water is constantly flowing aft, that being the lowest part. From this moisture there arises, at times, a most unpleasant bilge odor, but it is becoming less and less all the time. On the trip across the Atlantic, where the ship encountered bad weather, a quantity of chips and shavings were removed from the bilge strainers and bilges, notwithstanding the bilges had been cleaned before the ship was placed in commission.

No doubt these chips were washed down from between the timbers and it is highly probable that the intensely disagreeable stench from the bilges which came through the openings into the officers' rooms, in the early part of the cruise, arose from the decay of these shavings and chips. Forward of the boilers there is a water tight bulk head, which is provided with sliding gates. These gates are raised, and the bilge of the fore hole is washed semi-weekly, the water flowing into the fireroom bilges, which is pumped dry, scraped and whitewashed.

The regulation inspection of the bilges of a ship upon going into commission has not in all cases been satisfactory, and unless some precaution be taken during the building of our vessels, we may expect to have stinking bilges for the first three months of the cruise.

Fire Pumps.

The two auxiliary steam pumps discharge, each, into a vertical copper pipe which has a hose coupling on the spar, gun and berth decks and in the engine rooms, making an aggregate of eight connections for hose.

These hose are of the regulation size, and the muzzles are 1" inch in diameter of opening. There are three hand pumps on the berth deck, which are used at fire quarters and are used also, for washing decks when the ship is not under steam. These pumps, which were built at the New York Yard, do most excellent service. There are nine pumps of the "Rogers" patent situated in different parts of the ship, all of which are deficient, and six of them have already been condemned by survey. There is one point which I observed in the French ship "Richelieu," which I will take the liberty of mentioning. At the forward end of the fireroom, and recessed into the forward coal bunker, there is a large niche containing troughs in which the firemen wash. A grating forms the floor and under it there is a tank for receiving the soapy water. An opening from the bottom of this tank to the suction side of a donkey pump, permits it to be emptied without the necessity of the soapy water going into the bilge. A shower bath is also here provided for these men. It appears to me that this is a valuable improvement and that the space occupied by this wash room might be slightly enlarged to accommodate a steam fire engine. As it requires two hours, under favorable circumstances, to raise steam in the main boilers, and with the inadequate deck pumps that are supplied, a steam fire engine of such size that it could be carried in the launch, would be valuable, not only to the ship carrying it, but to other shipping in the harbor. For use on board, the machine need be brought only to the middle of the fire room, where its gases would be discharged into the main smoke pipe, while its discharge could be coupled to the vertical hose pipe already described, and its suction to couplings that could be easily improvised.

LENGTH OF VOYAGE.

On examination of the steam log book for the quarter ending June 30th, 1877, we find that there were six hours during which the ship's steaming was not influenced by wind or sea. This occurred during the run from Gibraltar to Villefranche. The length of voyage depends directly upon the economic performance of the machinery and weight of combustible carried in the bunkers.

This six hours run furnished all the data that I have for estimating the distance the vessel can steam. When working at high powers the engine works more economically than at low powers. What the exact difference will be, I am, of course, unable to say, but from the performance of other engines, the data of which are in my possession, I have estimated this rate.

The power is estimated to vary as the cube of the speed, and is calculated from the six hours performance, with half boiler power, the record of which run is as follows:

PERFORMANCE OF THE ENGINE.

Number of hours,		6
Mean speed in geographical miles per hour,		11.44
Mean pressure in the boilers in pounds above the atmosphere,		64.
Mean pressure in the receiver in pounds above zero,		18.84
Mean number of revolutions of the engine per minute,		43.6
Mean vacuum in the condenser in inches of mercury,		20.
Mean number of holes of the throttle open,		2.
Distance travelled by the pistons in inches when the steam was cut off,	High pressure,	21.
	Low pressure,	30.
TEMPERATURES IN DEG. FAHR. Engine room,		77.
External atmosphere,		65.
Injection water,		62.
Discharge water,		113.
Feed water,		127.
DRAUGHT OF WATER. Forward,		19 ft. 7 in.
Aft,		21 ft. 5 in.
Mean,		20 ft. 6 in.
Mean number of pounds of coal consumed per hour,		2773
Indicated horse power developed by the engine,		1300
Mean number of pounds of coal per I. H. P. per hour,		2.133

The bunkers can be stowed with 316 tons of coal and $\frac{316 \times 2240}{2773} = 256$ hours, or 10⅔ days, or 2929 nautical miles at the rate of speed above recorded.

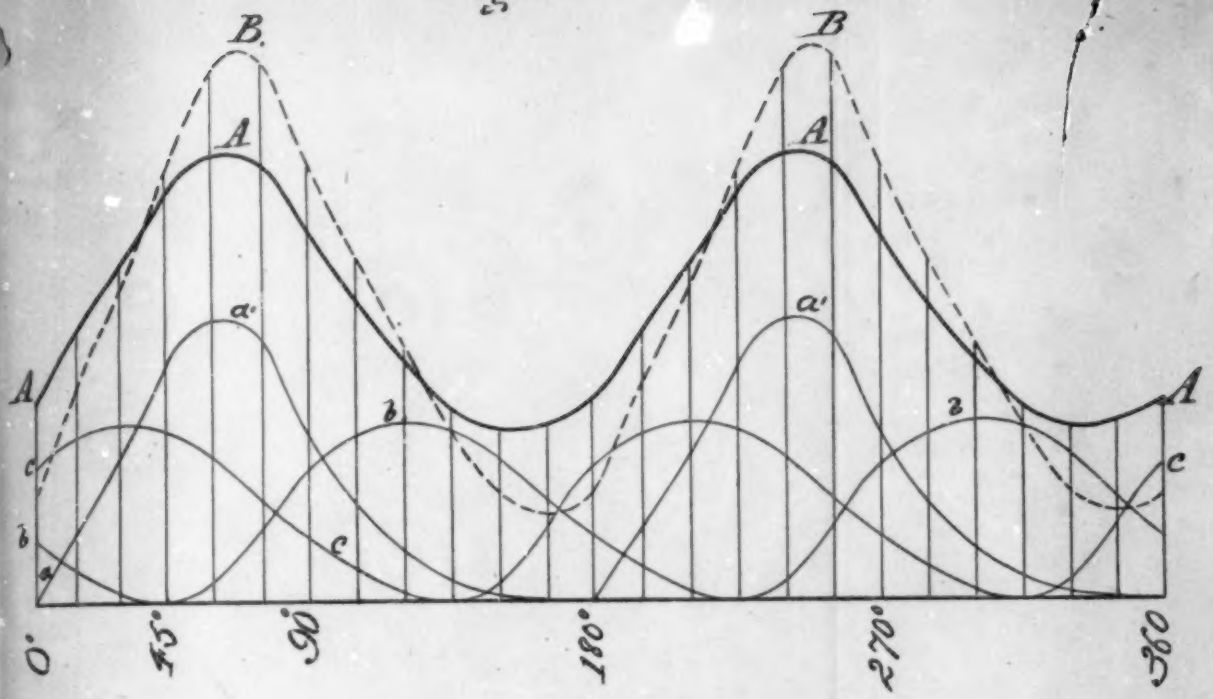
LENGTH OF VOYAGE AT DIFFERENT SPEEDS.

Speed in geographical miles per hour.	Pounds of coal per I. H. P. per hour.	Indicated horse power devel'p'd by the engine.	Total no. of hours steaming.	Total no. of days steaming.	To'l steaming dis. in geographical miles.
14.50	2,000	2,647	133	5.54	1,928
14.00	2,000	2,383	148	6.13	2,072
12.50	2,000	1,695	209	8.71	2,611
11.44	2,133	1,300	256	10.66	2,929
10.50	2,250	1,015	310	15.40	3,255
9.00	2,750	633	406	16.90	3,654
8.33	3,250	503	469	19.12	3,824

The vessel has been usually underlogged, and there is good reason to believe that the speed of 11.44 knots was attained fairly, during the period above referred to. The passage from Gibralter to Villefranche was favorable, so far as weather is concerned, for whenever the wind blew at all it was favorable.

TIME.	Total time the engines were in operation in hours and minutes,	71–23
REVOLUTIONS.	Total number,	179759
	Mean number per minute,	42.7
SPEED.	Total number of geographical miles per log-line,	765.5
	Total number of geographical miles per chart,	806.0
	Mean num'r of geographical mls. per hour, per log-line,	10.8
	Mean number of geographical mls. per hour, per chart,	11.29
COAL.	Total number of tons of coal consumed,	89 $\frac{1710}{2240}$
	Mean number of pounds of coal consumed per hour,	2970
DRAUGHT.	Mean draught of water for the run, in feet and inches,	20–5

Fig. 1.



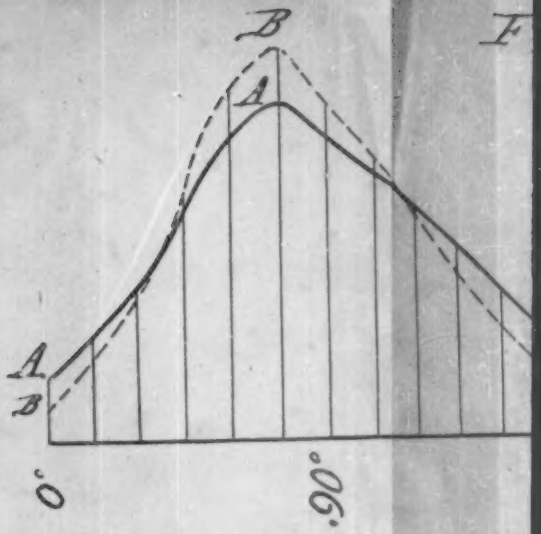
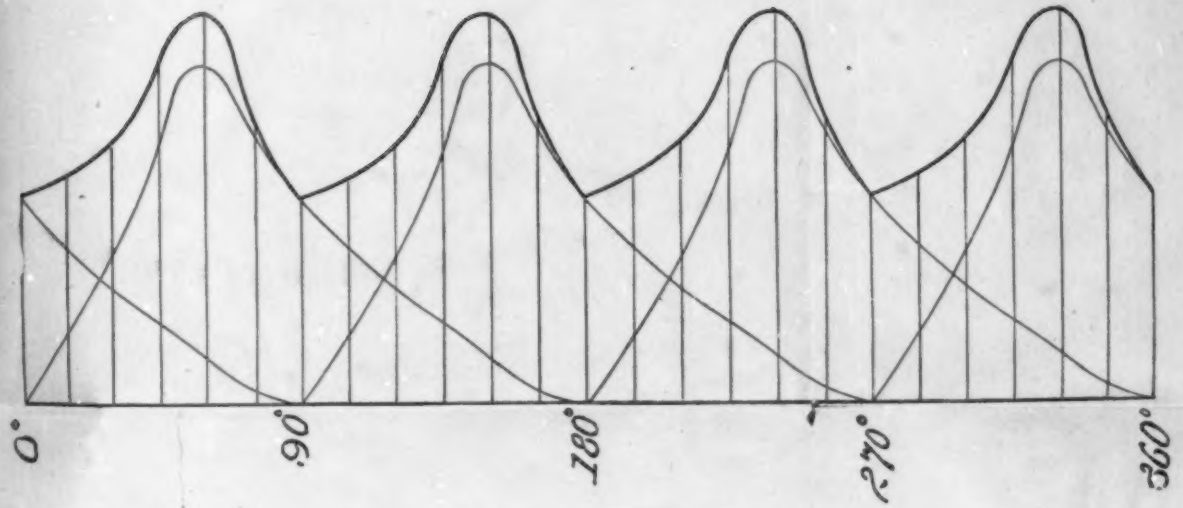
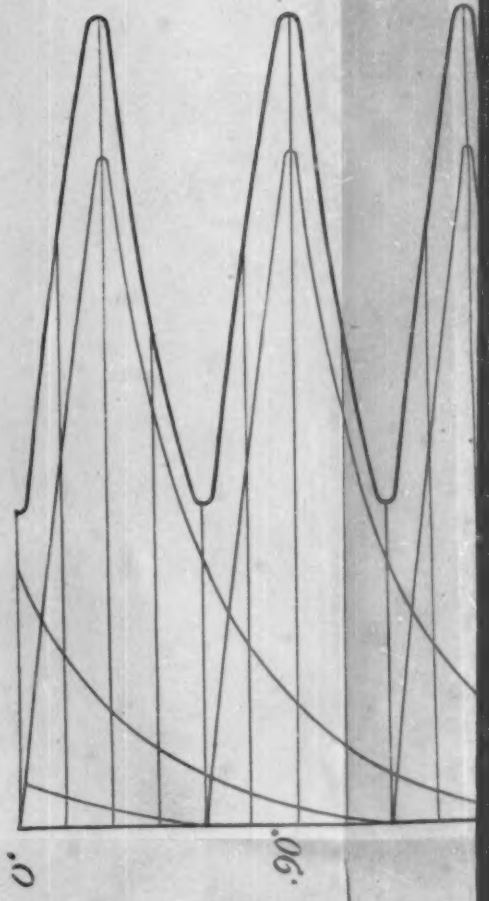


Fig. 3.





B
A
A
B
0°
90°
A
a
c
270°
360°
0°
90°
270°
360°

Fig. 2.

Fig. 4